Sources

Is there an interest to be raised by looking at microstructure of continent?

Issue about GPS vectors indication rotation – superposed on top of basic structure of subduction / basin-range

Not as significant to dams as overall reflected in geology

If difference in source type use appropriate attenuation relationship

Is this an argument to use probabilistic?

PSHA appropriate to rank fault and select sources

Define source and mechanism

In given part of NW (east of cascades, west of cascades, intermountain, etc) may be able to characterize general type of faulting of interest

Sources – should be able to summarize sources through field work on geology and an appropriate "random" event

Blind faults are not random events – based on structure

"Random" - uncertainty due to not being able to see faults by expression or seismicty

1872 Event

Was a major event

Moved around in 70s – away from particular project?

Bakun paper appears reasonable and well based

Not random – significant belts of faulting in area

Area is relatively active

Whole belt may be capable of producing an EQ of this magnitude

Not a lot of strain build up – may take a long time to develop large stress

A single EQ doesn't change stress field all that much

No surface rupture in 1872 event but there is expression from other events

1872 likely blind thrust – type of structure is indicative of blind thrust

Are all blind faults thrust?

Not much in literature of folds being caused by normal faulting; models use thrust

When dealing with areal source, how to determine mag/distance

Can look at history of area; utilize depth of local seismicity to pick distance

Others use near filed far field boundary distance – about 20 km

Not many major EQs real shallow. Most at 10-12 km Not many much deeper either

Based on temperature of rocks, can pick a maximum depth that can support the rupture

Blind thrust may come within 4 km of surface

By using depth as distance, by default you're putting it right under dam

To decide distance, use depth as a proxy to select distance

Not necessarily saying it happens right below dam, saying it may occur at that distance

Need some physical reason for selection of distance

Source ID – for a site, could use a potential fault as a source when the feature is uncertain – magnitude, length, distance, etc. – what are its characteristics

Degree of activity – what goes into evaluation as active faults?

Determination depends to some extent on knowledge about faults. San Andreas better understood – PNW less so

Slip rates

Issue for both probabilistic and deterministic –

Low slip rates does not mean that it's not active or can not produce large events

In a probabilistic analysis, can factor in

USGS hazard maps show raised levels in some areas due to faults that don't show recent movement

How handle rare catastrophic event?

The further I go back in geologic history the bigger the event – characteristic event provides a limit to size of event

Historical seismicity for smaller events

For bigger events can use paleo data, slip rates, etc. Get bigger events than predicted by Richter-Guttenberg

Given a fault – how determine magnitude

Some large magnitude events are more important

Is there a significant difference between events of different magnitudes close to the site

Consideration of fault capable – Different agencies utilize different ages as cutoff

USACE – 35,00 +/-

USBR – 100.000 +/-

CA DSOD – 10,000 +/-

Assigning magnitude to random events

5.5 – 6.5 larger should see source

Degree of activity vs. selection of median or +1 std dev

Is this more policy than science

Is this more important for deterministic as opposed to probabilistic?

Not necessarily based on science

Are there no random events – is it due to our lack of knowledge?

Applying best science but then putting policy on back end

CA DSOD may consider some point in between – how important is it given the assessment of the dam and its possible remediation

Policy issue for USACE – looking down road of using probability and RA need to be consistent – especially so for RA – confidence level – cascading conservatism

CA DSOD has a hazard consequence matrix should we consider

Attenuation relationships – how address duration of importance for very large (subduction) events

Long events may have cumulative effect on dam

Magnitude has saturation at high ends

For very large events – how much of time of event impacts a given location

Determination of vertical component

There are a couple of relationships in literature – may be very important if close in (10-15 km) – at distance it becomes less importance

Key component is in frequency content

Deterministic has build in simplified probabilistic approach
Probabilistic is a more formal approach

Event – response of struct – conseq all play into safety evaluation – owners/regulators /society want to understand risk

Out of probabilistic analysis get out deterministic events – need to look it over and se if it makes sense

Always looking at acceptable level of risk for project – often use prob of EQ as proxy for risk

Can’t forget capacity of dam when discussing probability of event

Acceptability of using USGS hazard maps

How to compare

Can download all output from model so can get idea of modes affecting the values

Hope that USGS doesn't carry more weight than a good site specific study

If something goes wrong and a lower value is used, could get into legal troubles

Need to explain any difference high or low

USACE NWD uses Don Yule process for preliminary eval then use site specific evaluation if appropriate – generally get higher values due to critical nature of structures

Need to discuss time – histories

What do we need to know for an analysis of a dam

Time histories for NW

Intra-plate, inter-plate and crustal as appropriate for site

Don't choose one history for each type

USACE uses 3 min, 5 min for non-linear, if use median values use at least 7

BC Hydro uses a prob approach – select 3-5 or more records as candidates for analysis – try to scale as little as possible, prefer to use multiple time histories to bracket response, usually use one synthetic time history

No close in records for mag 9 what synthetic do you use

Woodward Clyde developed one a while back but it was too high in some areas

Some Japanese records have been used

There are a couple of 8.3 +/- in database that can be used at 60-80 km so they may be appropriate for cascadia events

Limits of knowledge and analysis programs limit results to "is the result reasonable" Need to evaluate results not just accept

Is there a general consensus of time histories to use in the PNW?

Depends on geology across region

For a particular site, could we reach consensus or would there be wide disagreement

It's subjective – may be multiple events that are acceptable

Selection/modification of time histories is a "black art" and is contentious. UCB is setting up group to work on this issue

Difference in using median vs 84th may give up to 50% variation in response in some

non-linear analyses

People involved affects suite of time histories that they like to use

Variability between different time histories is on the order of 80% log normal

For Bay Bridge saw very wide variability in results

UCB working on way to select critical record objectively

Portland area is less well understood
- GPS has the capability to help with this

Post seismic performance need to look at more than one scenario

Strategies

Let the geology/ seismology drive the selection of sources / mechanisms

Time histories: Repeatable, realistic, use a suite (25- gives 20% uncertainty in response – more gives you lowered variability) To 7 for analyses

Geotechnical / structural engineer should contribute to team

Random sources should be associated with Regional picture

Pull together working group to work on
- What do we have today
- Come up with a framework for PSHA
- Trying to develop reasonable ground motions for use
- Fragility curves to relate structure to uncontrolled release of water
- Need to move toward risk
- How to use results
- In lower activity areas likely to reach point of just do it

Concept of reliability vs risk - what should we be considering given the ever changing consequences d/s

Relate return period to ability to control release of water – this may require development

of fragility curves

What’s the appropriate levels of redundancy, strengths etc. in our structures

We don’t have a really good idea of what ground motions that would cause unacceptable performance in dam due to un-quantified level of conservatism in analyses

Develop standing regional / national working group to define issues related to dam safety and develop recommendations for implementation

How to appropriately utilize USGS seismic hazard information – utilize as comparison, for screening, need to understand differences and comment on,